

**Guidance for the use of the Synthetic Precipitation Leaching Procedure to
Develop Site-Specific Impact to Ground Water Remediation Standards**

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I. Introduction

The Synthetic Precipitation Leaching Procedure (SPLP) is one method identified by the Department that may be used to develop a site-specific impact to groundwater soil remediation standard. This guidance provides procedures that the person responsible for conducting the remediation may use to develop remediation standards for low volatility organic and inorganic contaminants. It is not appropriate to use this method to develop remediation standards for volatile organic contaminants.

These procedures may be used at any time during the remediation process provided that sufficient site data and information are available on which to base a standard. The Department strongly recommends that the person conducting the remediation submit the site-specific standard developed based on the methods described in this guidance and by using the spreadsheet that has been prepared for this purpose. Site-specific standards should be submitted to the assigned case manager prior to implementing the remedial action at a site.

Through the use of this guidance, the person conducting the remediation will 1) either select or develop a leachate criterion; 2) evaluate their site-specific data in relation to that criterion; and then 3) use this information to determine their site-specific impact to ground water soil remediation standard.

The Department has provided a multi-faceted spreadsheet that will enable the person conducting the remediation to quickly and easily generate soil remediation standards that will be protective of ground water for any given site. Hyperlinks to the spreadsheet are provided throughout this guidance.

http://www.nj.gov/dep/srp/guidance/rs/splp_spreadsheet.xls

II. Background

The Synthetic Precipitation Leaching Procedure (SPLP) is an EPA SW-846 analytical method (Method 1312) that can be used to determine the concentration of contaminant that will leach from soil (USEPA, 1998). SPLP offers a quick and inexpensive method to develop remediation criteria that will be protective of ground water at a specific site. Additional background information regarding this test method is provided in Appendix B of this guidance. SPLP may also be used to develop an adsorption constant (K_d), which may be used in other procedures to develop a site-specific impact to ground water remediation standard.

The SPLP procedure may only be used to develop site specific soil remediation standards for low volatility organic compounds and inorganic compounds. For reasons discussed in Appendix B, the procedure may often be the method of choice for determining cleanup standards for inorganic and low mobility organic compounds. Low mobility organic compounds may be conveniently defined as those with K_{oc} values greater than 20,000 L/kg (Roy and Griffin, 1985), and these values may be looked up in the chemical properties table in the Inhalation Soil Standards Basis and Background Document, or at the following link:
<http://www.nj.gov/dep/srp/guidance/rs/chemproperties.pdf>

It is not appropriate to use SPLP for volatile organic contaminants because volatile organic soil samples must be collected using either methanol preservation or the Encore[®] sampler. Methanol cannot be added to an SPLP sample because it affects contaminant desorption. Additionally, the Encore[®] sampler comes in 5 or 25 gram sizes, which would require the collection of multiple samples to achieve the required sample size for the SPLP test and total soil analysis. These separate samples would need to be composited, which is difficult to accomplish without loss of volatile organic contaminants. Volatile contaminants are defined as those with Henry's law constants greater than 10^{-5} atm m⁻³ mol⁻¹ and vapor pressures greater than 1 mm Hg at 25°C (NJDEP 2005).

III. Selecting or Developing a Leachate Criterion

A. Selecting a Default Leachate Criterion

The person conducting the remediation may select the Leachate Criterion from the table of Default Leachate Criteria provided in Appendix A of this guidance. The Department recommends that the Leachate Criterion in Appendix A be used when no, or very little site specific information is available. This table includes:

1. Health-based ground water quality criterion for low volatility organic contaminants and inorganic contaminants from the Ground Water Quality Standards, N.J.A.C. 7:9C, for Class II ground water;
2. Health-based Leachate Criteria, which is the ground water quality criterion multiplied by a default dilution attenuation factor (DAF) of 13;
3. Aqueous Practical Quantitation Levels (PQLs) from the Ground Water Quality Standards, N.J.A.C. 7:9C; and
4. Higher of the health-based Leachate Criteria or the PQL.

For chemicals listed in Appendix A, steps 1-4 above are incorporated into the SPLP spreadsheet provided by the Department. The user need only to select the chemical.

For Class I and Class III ground water, the Department must first develop ground water quality criteria pursuant to N.J.A.C. 7:9C. Impact to ground water soil remediation standards can then be developed based on those Class I and Class III ground water quality criteria. Then a site-specific soil remediation standard can then be calculated following the procedure described above.

B. Developing a Site-Specific Leachate Criterion

The person conducting the remediation may develop a site-specific Leachate Criteria using a site-specific DAF. The Department has provided guidance and a spreadsheet for the development of a site-specific DAF.

http://www.nj.gov/dep/srp/guidance/rs/splp_spreadsheet.xls

To develop a site-specific Leachate Criteria once a site-specific DAF is developed the person conducting the remediation must:

1. Determine the health-based ground water quality criterion from the Ground Water Quality Standards, N.J.A.C. 7:9C, for Class II ground water (provided in Appendix A);
2. Multiply the ground water quality criterion by the site-specific DAF;
3. Select the higher of the Leachate Criteria or the aqueous PQLs from the Ground Water Quality Standards, N.J.A.C. 7:9C; and
4. Ensure that the Leachate Criteria does not exceed the water solubility of the contaminant (inorganic contaminants excepted)

For chemicals listed in Appendix A, steps 1-4 above are automatically calculated using the SPLP spreadsheet provided by the department. The user need only select the chemical and enter the site-specific DAF.

For Class I and Class III ground water, the Department must first develop ground water quality criteria pursuant to N.J.A.C. 7:9C. Impact to ground water soil remediation standards can then be developed based on those Class I and Class III ground water quality criteria. Then a site-specific soil remediation standard can then be calculated following the procedure described above. The Department should be consulted on the use of the spreadsheet in these cases.

IV. Instructions for soil sampling and conducting the SPLP test

A. Sampling and Analysis

1. Ensure that a sufficient volume of soil is collected so that both the SPLP test (100g soil required) and total contaminant analysis (5-25g soil required) can be conducted. Leachate concentrations and total contaminant concentrations are interrelated and the correlation of these data can be used when remediating the site. Before the samples are split for SPLP and total contaminant analysis, the samples must be thoroughly mixed to yield uniform contaminant concentrations.
2. Collect a minimum of three soil samples for each area of concern. The number of samples collected shall be determined by the size of the area initially being investigated pursuant to the Technical Rules. The samples should include the highest suspected concentrations of the

contaminants on site. Samples that represent a range of contaminant concentrations will be useful in using the procedures described below if some or all of the SPLP results exhibit unacceptable leachate concentrations. The samples should be representative of the variation in soil conditions over the area of concern, including variation with soil depth. After thoroughly mixing, split each sample and analyze as described below.

i. One sub-sample must be analyzed for total contaminant concentrations for the contaminants of concern using appropriate methods as listed in the Technical Rules (N.J.A.C. 7:26E).

ii. One sub-sample must be applied to the SPLP procedure described in USEPA SW-846, Analytical Method 1312.

iii. Measure the pH of the leachate sample at the conclusion of the SPLP extraction procedure.

iv. Analyze the leachate for the contaminants of concern using appropriate methods as listed in the Technical Rules (N.J.A.C. 7:26E).

v. For each sample and each contaminant provide the following information in tabular form:

- The total contaminant concentration in the soil, C_T
- The leachate concentration, C_L
- The adjusted leachate concentration, C_{adj} , if necessary (see below);
- The final pH of the leachate
- The volume of the leachate, V_L
- The dry weight of the soil sub-sample used in the SPLP test

vi. Additional soil samples may need to be collected for SPLP testing if:

- If delineation conducted subsequent to earlier SPLP testing determines that soil contamination extends to a different soil type or depth not yet evaluated. Because soil properties often vary with depth, subsurface soil samples should be included if the contamination extends below the surface soil.
- If delineation conducted subsequent to earlier SPLP testing determines that soil contaminant concentrations are higher than concentrations initially measured.

B. Adjustment of leachate concentrations for weakly adsorbed contaminants

In some cases, contaminants may be weakly adsorbed to soil particles. This may be due to a contaminant's low adsorption constant, the nature of the soil or the magnitude or age of the contaminant discharge. When contaminants are weakly adsorbed, the SPLP test may underestimate concentrations that would be observed under natural conditions because the large amount of extracting solution used dilutes the contaminant and the resulting soil remediation standard would not be adequately protective. A contaminant is considered to be weakly adsorbed to soil when the contaminant mass in the leachate solution is more than 25% of the total contaminant concentration.

When it is determined that contaminants are weakly adsorbed to the soil the person conducting the remediation should adjust the leachate concentration as follows:

1. Determine the percent of contaminant mass in the SPLP leachate using Equation 1 below:

$$(C_L \times V_L) / (C_T \times M_S) \times 100 \quad \text{Equation 1}$$

where

V_L is the volume of leachate in liters (2 L)

M_S is the mass of the soil sample in kilograms (0.1 kg)

C_L is the leachate concentration (mg/L)

C_T is the total soil concentration (mg/kg)

NOTE: C_L in Equation 1 must have units of mg/L

2. If the percent of contaminant mass in the leachate is 25 or greater, calculate a K_d value for the contaminant in each sample using Equation 2 below:

$$K_d = \frac{(C_T M_S - C_L V_L) / M_S}{C_L} \quad \text{Equation 2}$$

where

K_d = is the soil water partition coefficient (L/kg)

C_T = the total concentration of the contaminant in the SPLP soil sample (mg/kg)

M_S = the total weight of the soil sample submitted for SPLP analysis (0.1 kg)

C_L = the concentration of contaminant in the SPLP leachate (mg/L)

V_L = the volume of the SPLP leachate (2 L)

NOTE: C_L in Equation 2 must have units of mg/L

The derivation of Equation 2 is provided in Appendix C.

3. For each sample, substitute the K_d value in the following equation to calculate an adjusted leachate concentration:

$$C_{adj} = C_T[\rho_b / (K_d \times \rho_b + \theta_w)] \quad \text{Equation 3}$$

where

ρ_b = bulk density of the soil (1.5 kg/L)

θ_w = soil moisture (0.23)

C_{adj} = adjusted leachate concentration (mg/L).

Equation 3 is a simple rearrangement of the USEPA Soil Screening Guidance soil-water partition equation (no air phase) (USEPA, 1996).

4. Use C_{adj} in place of C_L as needed in the options below.

Further discussion pertaining to weakly adsorbed contaminants is provided in Appendix D. The Department spreadsheet provided for the SPLP test automatically calculates the adjustment of leachate concentration for weakly adsorbed contaminants.

http://www.nj.gov/dep/srp/guidance/rs/splp_spreadsheet.xls

C. Using SPLP Results to Determine a Site-Specific Impact to Ground Water Soil Remediation Standard

The three options are provided below allow the person responsible for conducting the remediation to determine a site-specific impact to ground water soil remediation standard using SPLP results. The Department has provided a spreadsheet on its web site that will calculate site-specific impact to ground water soil remediation standards using site-specific analytical data for each suitable option listed below, depending on the nature of the SPLP dataset.

http://www.nj.gov/dep/srp/guidance/rs/splp_spreadsheet.xls

Option 1. Determination of a Site-Specific Soil Remediation Standard from SPLP Data Arranged in Tabular Format

Prepare a table of total soil concentrations in ascending order and SPLP leachate concentrations. Compare the SPLP leachate (or adjusted leachate) concentration for each sample to the Leachate Criterion as follows:

1. If all SPLP leachate (or adjusted leachate) concentrations are at or below the Leachate Criterion, the highest total soil concentration tested can be used as a site-specific soil cleanup remediation standard. If this site-specific soil cleanup remediation standard is the highest concentration of the contaminant for the AOC, then no further investigation is required for the impact to ground water pathway for that AOC; and

2. If one or more of the SPLP leachate (or adjusted leachate) concentrations are above the Leachate Criterion, select the highest soil concentration for which this, and all lower soil concentrations, have leachate (or adjusted leachate) concentrations at or below the Leachate Criterion. This concentration can be used as a site-specific soil remediation standard.

Two examples are provided below to illustrate this approach:

Example 1

Area of Concern 1

Sample Number	Contaminant Concentration in Soil $C_T(\text{mg/kg})$	Contaminant Concentration in Leachate $C_L(\mu\text{g/L})$	Leachate Criterion LC ($\mu\text{g/L}$)
Sample 1	5	900	2600
Sample 2	10	1200	2600
Sample 3	30	2280	2600
Sample 4	50	1680	2600
Sample 5	75	2700	2600

where

C_T = the total concentration of the contaminant in the SPLP soil sample (mg/kg)

C_L = Concentration of contaminant in the SPLP leachate ($\mu\text{g/L}$)

LC = Leachate Criterion

In example 1 above, the Leachate Criterion for the contaminant of concern is 2600 $\mu\text{g/L}$. The soil concentration for sample 4 (50 mg/kg) and all lower soil concentrations tested resulted in leachate concentrations below the leachate criterion. Therefore, the impact to ground water soil remediation standard for Area of Concern 1 is 50 mg/kg.

Example 2

Area of Concern 2

Sample Number	Contaminant Concentration in Soil $C_T(\text{mg/kg})$	Contaminant Concentration in Leachate $C_L(\mu\text{g/L})$	Leachate Criterion LC ($\mu\text{g/L}$)
Sample 1	5	900	1950
Sample 2	10	1200	1950
Sample 3	30	2280	1950
Sample 4	50	1680	1950
Sample 5	75	2700	1950

In example 2 above, the Leachate Criterion for the contaminant of concern is 1950 µg/L. Sample 2 has the highest soil concentration (10 mg/kg) for which all this and all lower soil concentrations resulted in leachate concentrations that are at or below the leachate criterion. Even though Sample 4 passed the SPLP test, a sample with a lower soil concentration (Sample 3) did not. Therefore, the impact to ground water soil remediation standard for Area of Concern 2 is 10 mg/kg.

Option 2. Determination of a Site-Specific Soil Remediation Standard using a Site-Specific K_d value

Sample-specific K_d values can be calculated using the total contaminant concentration in a soil sample (C_T) and the SPLP leachate concentration (C_L). These sample-specific K_d values may be used to determine a site-specific K_d value. This site-specific value is then used to determine a site-specific soil remediation standard as follows:

1. Use the total contaminant concentration in a soil sample (C_T), and the corresponding SPLP leachate concentration (C_L) in Equation 2 above to calculate a sample-specific soil-water partition coefficient (K_d);
2. Prepare a table of the calculated K_d values;
3. If the K_d values of all the samples vary by less than an order of magnitude, calculate the average K_d . If the K_d values of all the samples vary by more than an order of magnitude, select the lowest calculated K_d .
4. Substitute the site-specific partition coefficient (K_d) into Equation 4 to calculate a site-specific soil cleanup criterion:

$$IGWSRS = LC \left\{ \left[K_d \right] + \frac{\theta_w + \theta_a H'}{\rho_b} \right\} \quad \text{Equation 4}$$

where

$IGWSRS$ = Impact to Groundwater Soil Remediation Standard (mg/kg)

LC = Leachate criterion (mg/L)

K_d = is the average, or lowest, calculated sample specific soil-water partition coefficient (L/kg)

θ_w = the volume fraction of water in the original soil sample (0.23)

θ_a = the volume fraction of air in the original water sample (0.18)

H' = the dimensionless Henry's law constant for the contaminant of interest

ρ_b = the dry soil bulk density (1.5 kg/L)

Equation 4 is equivalent to the soil-water partition coefficient described in the USEPA Soil Screening Guidance document (USEPA, 1996). The Leachate Criterion (health-based ground water criteria x DAF) is equivalent to EPA's target leachate concentration. Henry's law constants may be found in the Inhalation Soil Standards Basis and Background Document or at the following link: <http://www.nj.gov/dep/srp/guidance/rs/chemproperties.pdf>

Option 3. Determination of a Site-Specific Soil Remediation Standard using SPLP results and Linear Regression Analysis

A linear regression technique may be used to determine a site-specific soil remediation standard if an adequate linear correlation exists between leachate (or adjusted leachate) concentrations and the corresponding total soil contaminant concentrations. Conduct the linear regression as follows:

1. For all samples where both the total soil concentration and the leachate (or adjusted leachate) concentration are above the PQL, plot the leachate (or adjusted leachate) concentration data (in units of µg/L) on the y-axis as the dependant variable versus the total soil concentrations for all samples (in units of mg/kg) on the x-axis as the independent variable;

2. Determine if the data qualifies for a linear correlation test:

At least half of the total soil concentration data points must lie at or above the midpoint of the range of total soil concentrations;

The calculated Leachate Criterion (*LC*) must lie within the range of measured leachate (or adjusted leachate) concentrations; and

The R-Square value for the linear least-squares regression analysis of the plotted points must be 0.7 or higher.

3. Calculate the site-specific soil remediation standard using Equation 5 below:

$$IGWSRS = \frac{LC - b}{m} \quad \text{Equation 5}$$

where

IGWSRS = the impact-to-ground water soil cleanup criterion (mg/kg)

LC = the Leachate Criterion (µg/L)

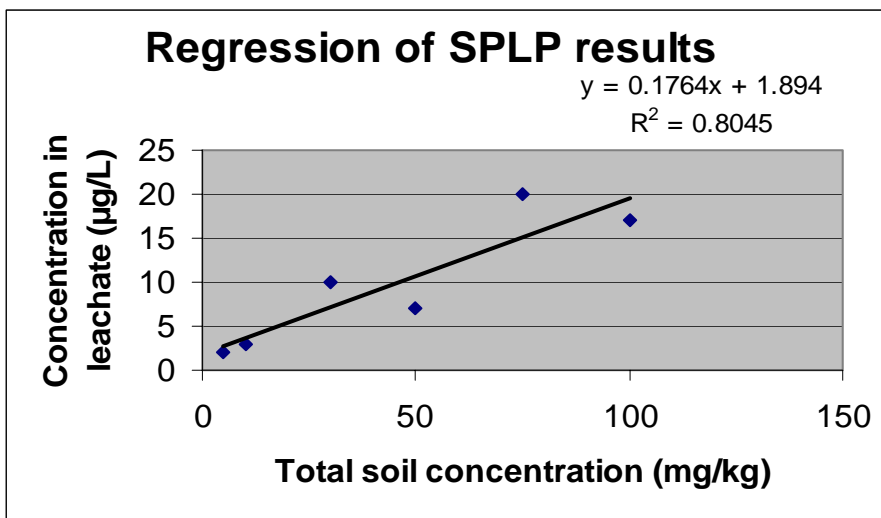
m = the slope of the best fit line obtained via linear regression analysis ((µg/L)/(mg/kg))

b = the intercept of the best fit line obtained via linear regression (µg/L)

Example 3

Area of Concern 3

Sample Number	Contaminant Concentration in Soil $C_T(\text{mg/kg})$	Contaminant Concentration in Leachate $C_L(\mu\text{g/L})$	Leachate Criterion LC ($\mu\text{g/L}$)
Sample 1	5	2	10
Sample 2	10	3	10
Sample 3	30	10	10
Sample 4	50	7	10
Sample 5	75	20	10
Sample 6	100	17	10



$$\text{IGWSRS} = (10\mu\text{g/L} - 1.89\mu\text{g/L}) / 0.176(\mu\text{g/L}) / (\text{mg/kg}) = 46 \text{ mg/kg}$$

Using the example data in equation 5, the soil remediation standard for area of concern 3 would be 46 mg/kg.

D. Submission requirements

In order for case managers to efficiently review proposed site-specific soil remediation standards, the Department recommends that the person responsible for conducting the remediation use the spreadsheet provided by the Department at http://www.nj.gov/dep/srp/guidance/rs/splp_spreadsheet.xls . The following parameters are needed for each sample and for each contaminant of concern:

- Sample number
- The total contaminant concentration in the soil (C_T)
- The leachate concentration (C_L)
- The adjusted leachate concentration, if necessary (C_{adj})

- The final pH of the leachate
- The volume of the leachate (V_L)
- The dry weight of the soil-sub sample used in the SPLP test (M_S)

It is also strongly suggested that other properties and information related to the soil samples be reported if they are available (e.g. depth of sample, soil texture information, soil organic matter, etc.)

In addition to above required parameters, the spreadsheet also displays the calculated K_d values, and calculates and displays the results of the three SPLP options discussed above. Both a hard copy and an electronic copy of the filled out spreadsheet should be submitted to the Department.

APPENDIX A
Default Leachate Criteria
for Class II Ground Water (ug/L)

<u>Contaminant</u>	<u>CAS Number</u>	Health Based Groundwater Quality Criterion	Impact to GW Health Based Leachate Criterion	Aqueous POL	Higher of the Health-based Leachate Criterion or POL
Acenaphthene	83-32-9	400	5,200	10	4,240*
Acetophenone	98-86-2	700	9,100	10	9,100
Aldrin	309-00-2	0.002	0.03	0.04	0.04
Aluminum	7429-90-5	200	2,600	30	43*
Anthracene	120-12-7	2,000	26,000	10	26,000
Antimony	7440-36-0	6	78	3	78
Arsenic	7440-38-2	0.02	0.3	3	3
Atrazine	1912-24-9	3	39	0.1	39
Barium	7440-39-3	6,000	78,000	200	78,000
Benidine	92-87-5	0.0002	0.0026	20	20
Benzo(a)anthracene (1,2-Benzanthracene)	56-55-3	0.05	0.6	0.1	0.6
Benzo(a)pyrene	50-32-8	0.005	0.06	0.1	0.1
Benzo(b)fluoranthene (3,4-Benzofluoranthene)	205-99-2	0.05	0.6	0.2	0.6
Benzo(ghi)perylene	191-24-2	NA	NA	0.2	NA
Benzo(k)fluoranthene	207-08-9	0.5	6	0.3	0.8*
Beryllium	7440-41-7	1	13	1	13
1,1'-Biphenyl	92-52-4	400	5,200	10	5,200
Bis(2-chloroisopropyl)ether	108-60-1	300	3,900	10	3,900
Bis(2-ethylhexyl)phthalate	117-81-7	2	26	3	26
Butyl benzyl phthalate	85-68-7	100	1300	1	1,300
Cadmium	7440-43-9	4	52	0.5	52
Chlordane (alpha and gamma)	57-74-9	0.01	0.1	0.5	0.5
Chrysene	218-01-9	5	65	0.2	1.6*
Cobalt	7440-48-4	NA	NA	2	NA
Copper	7440-50-8	1,300	16,900	4	16,900
Cyanide	57-12-5	100	1,300	6	1,300
4,4'-DDD	72-54-8	0.1	1	0.02	1
4,4'-DDE	72-55-9	0.1	1	0.01	1
4,4'-DDT	50-29-3	0.1	1	0.1	1
Dibenz(a,h)anthracene	53-70-3	0.005	0.06	0.3	0.3
1,2-Dibromo-3-chloropropane	96-12-8	0.02	0.26	0.02	0.26
3,3'-Dichlorobenzidine	91-94-1	0.08	1.0	30	30
2,4-Dichlorophenol	120-83-2	20	260	10	260
Dieldrin	60-57-1	0.002	0.03	0.03	0.03
Diethylphthalate	84-66-2	6,000	78,000	1	78,000
2,4-Dimethylphenol	105-67-9	100	1,300	20	1,300
Di-n-butyl phthalate	84-74-2	700	9,100	5	9,100
2,4-Dinitrophenol	51-28-5	10	130	40	130
Di-n-octyl phthalate	117-84-0	100	1,300	5	20*
2,4-Dinitrotoluene/2,6-Dinitrotoluene (mixture)	25321-14-6	0.05	0.6	10	10
1,2-Diphenylhydrazine	122-66-7	0.04	0.52	20	20

Endosulfan I and Endosulfan II	115-29-7	40	520	0.1	510*
Endosulfan sulfate	1031-07-8	40	520	0.02	520
Endrin	72-20-8	2	26	0.03	26
Fluoranthene	206-44-0	300	3,900	10	200*
Fluorene	86-73-7	300	3,900	1	1,980*
alpha-HCH (alpha BHC)	319-84-6	0.0006	0.078	0.02	0.078
beta-HCH (beta-BHC)	319-85-7	0.02	0.26	0.04	0.26
Heptachlor	76-44-8	0.008	0.1	0.05	0.1
Heptachlor epoxide	1024-57-3	0.004	0.05	0.2	0.2
Hexachlorobenzene	118-74-1	0.02	0.3	0.02	0.3
Hexachloro-1,3-butadiene	87-68-3	0.4	5	1	5
Hexachlorocyclopentadiene	77-47-4	40	520	0.5	520
Hexachloroethane	67-72-1	2	26	7	26
Lead	7439-92-1	5	65	5	65
Indeno(1,2,3-cd)pyrene	193-39-5	0.05	0.6	0.2	0.022*
Isophorone	78-59-1	40	520	10	520
Lindane (gamma-HCH) (gamma-BHC)	58-89-9	0.03	0.39	0.02	0.39
Manganese	7439-96-5	50	650	0.4	650
Mercury	7439-97-6	2	26	0.05	26
Methoxychlor	72-43-5	40	520	0.1	45*
2-Methylnaphthalene	91-57-6	30	390	10	390
Naphthalene	91-20-3	300	3,900	2	3,900
Nickel (Soluble salts)	7440-02-0	100	1,300	4	1,300
Nitrobenzene	98-95-3	4	52	6	52
N-Nitrosodimethylamine	62-75-9	0.0007	0.0091	0.8	0.8
N-Nitrosodi-n-propylamine	621-64-7	0.005	0.065	10	10
N-Nitrosodiphenylamine	86-30-6	7	91	10	91
Phenanthrene	85-01-8	NA	NA	0.4	NA
Polychlorinated biphenyls (PCBs)	81336-36-3	0.02	0.3	0.5	0.5
Pentachlorophenol	87-86-5	0.3	3.9	0.1	3.9
Phenol	108-95-2	2,000	26,000	10	26,000
Pyrene	129-00-0	200	2,600	0.1	140*
Selenium	7782-49-2	40	520	4	520
Silver	7440-22-4	40	520	1	520
Tertiary butyl alcohol (TBA)	75-65-0	100	1,300	2	1,300
Thallium	7440-28-0	0.5	6	2	6
Toxaphene	8001-35-2	0.03	0.4	2.0	2.0
1,2,4-Trichlorobenzene	120-82-1	9	120	1	120
2,4,5-Trichlorophenol	95-95-4	700	9,100	10	9,100
2,4,6-Trichlorophenol	88-06-2	1	13	20	20
Vanadium	7440-62-2	NA	NA	3	NA
Zinc	7440-66-6	2,000	26,000	10	26,000

* Adjusted so as not to exceed water solubility

APPENDIX B

Background information on Synthetic Precipitation Leaching Procedure

The SPLP test uses a USEPA SW-846 analytical method (Method 1312) that can be used to determine the concentration of contaminant that will leach from soil (USEPA, 1998). The SPLP offers a quick and inexpensive method to assess the mobility of contaminants in the soil. A particularly useful aspect of the SPLP procedure is that it measures desorption, rather than adsorption, of contaminants from soil. It is well known that adsorption of many contaminants to soil increases as contact time increases (Loehr and Webster, 1996; Alexander, 1995; Pavlostathis and Mathavan, 1992). This is particularly true for less mobile contaminants. In some cases, contaminants may become irreversibly adsorbed to soil and therefore immobile. Soil adsorption coefficients (and K_{oc} values) used in the USEPA SSL partition equation do not consider these processes. While the USEPA partition equation could be used with desorption, rather than adsorption coefficients, values for desorption coefficients are not generally available and if they are available they are likely to be site-specific.

Because the SPLP procedure uses the soil on site, it addresses species-specific issues regarding inorganic contaminants, particularly metals. The USEPA's soil-water partition equation assumes the most mobile form of an inorganic contaminant to estimate an adsorption coefficient for use in the partition equation (USEPA, 1996). Because the actual species (redox state, salt, or complex) of an inorganic contaminant at a discharge site is typically not known after the site investigation phase, this assumption is necessary in order to be adequately protective of all situations that may occur. The SPLP procedure, on the other hand, measures the leaching potential of the actual species of the contaminant present at the discharge site. Different species of metals can have widely varying mobility. Speciation is generally not known because standard analytical methods usually measure total metals only. The SPLP test will measure the actual mobility, regardless of species. While a detailed assessment of the results of this test may be complex when mixtures of different species of the same metal are present, the procedure nonetheless provides a much-improved estimate of leaching tendency.

The conditions of the SPLP test simulate actual environmental precipitation, in that the leaching solution is a simulation of mid-Atlantic rainfall (pH 4.2). Thus, the test more realistically estimates the leaching potential of contaminants that may occur under field conditions in New Jersey (Brown et al., 1996; Lackovic et al., 1997). Because the leaching test is conducted with actual soil samples taken from the site, remediation standards developed using this test are expected to be much more representative of site conditions than standards determined via other methods. SPLP can be easily and quickly conducted on samples during the site investigation in a time and cost efficient manner. For all of the reasons above, SPLP testing is employed as the default procedure for developing remediation criteria for inorganic and low volatility organic contaminants.

The limitations of the SPLP test are as follows. First, because leachate is filtered through a 0.6 - 0.8 μm filter, the concentration of colloidal inorganics above this pore size may be underestimated. Second, because the oxidation/reduction potential of the sample is not preserved

when the test is conducted, the interconversion of metal species with multiple oxidation states may occur.

APPENDIX C

Derivation of Equation 2

As explained in the USEPA Soil Screening Level Guidance Document (USEPA 1996), the equation for K_d is defined as the ratio, at equilibrium, of the contaminant concentration in the sorbed phase to that in the aqueous phase (Equation 12 in USEPA 1996):

$$K_d = \frac{C_s}{C_w}$$

where C_s is the sorbed concentration of contaminant (mg/kg), C_w is the aqueous phase concentration in soil water (mg/L), and K_d is the soil adsorption coefficient (L/kg). When using the SPLP procedure described in this document to determine a sample-specific K_d value or cleanup criteria, it is also necessary to determine the total soil concentration of contaminant, (C_T , mg/kg) in the sample prior to extraction. The total mass of contaminant in the soil sample may be therefore described as $C_T M_S$, where M_S is the dry weight of the soil sample submitted for SPLP testing (kg). After equilibration with leaching solution, the total mass of contaminant leached may be calculated as $C_L V_L$, where C_L is the concentration of contaminant in the leachate solution (mg/L), and V_L is the volume of leachate (L). This mass may be subtracted from the total mass of contaminant originally in the soil sample to give the mass of contaminant still adsorbed to the soil after the SPLP experiment. The equilibrium concentration of the contaminant in the sorbed phase after the SPLP experiment may then be calculated as

$$(C_T M_S - C_L V_L) / M_S.$$

Since the equilibrium aqueous phase concentration of contaminant after the SPLP extraction is C_L , the soil adsorption coefficient, K_d , may be expressed as

$$K_d = \frac{(C_T M_S - C_L V_L) / M_S}{C_L}.$$

APPENDIX D

Adjustment of leachate concentrations for weakly adsorbed chemicals

Often, contaminants subjected to the SPLP tests are highly adsorbed to the soil. For hazardous waste sites that have existed for many years, contaminants that are weakly adsorbed have already migrated away from the site. In cases where discharges are recent or very large in size, contaminants may still be relatively mobile (i.e., weakly adsorbed to soil) at the time of the site investigation. In these situations, the leachate concentration determined using the SPLP test may underestimate concentrations that would be observed under natural conditions because the large amount of extracting solution used dilutes the contaminant. The ratio of extracting solution weight to the soil weight employed in the SPLP test is 20 to 1. In contrast, a representative soil water to soil solids ratio in sandy loam soil in New Jersey is approximately 0.23 ml moisture to 1.5 grams of soil. The dilution error in the SPLP test becomes significant when approximately 25% of the contaminant is found in the leachate solution, or when the K_d is less than or equal to 50 L/kg:

Table 1			
Leachate concentration (mg/L) as a function of leaching volume			
K_d (L/kg)	Leachate concentration, natural conditions (0.23mL water per 1.5gram of soil)	Leachate concentration, SPLP conditions (20mL extractant per gram of soil)	% of contaminant in leachate
1	11.6	0.64	96
10	1.3	0.44	66
20	0.66	0.33	50
50	0.27	0.19	28
100	0.13	0.11	16

Total contaminant concentration (dry soil basis): 13.3mg/kg

Note that when K_d is less than 50 L/kg, the difference between the SPLP concentration and the natural field leachate concentration becomes significant. Therefore, the Department may require an alternative remediation standard be developed using adjusted leachate concentrations when site conditions indicate that contaminants may be weakly adsorbed to soil. Leachate concentrations measured in the SPLP test may need to be adjusted to reflect the soil-to-water ratios that exist under field conditions.

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